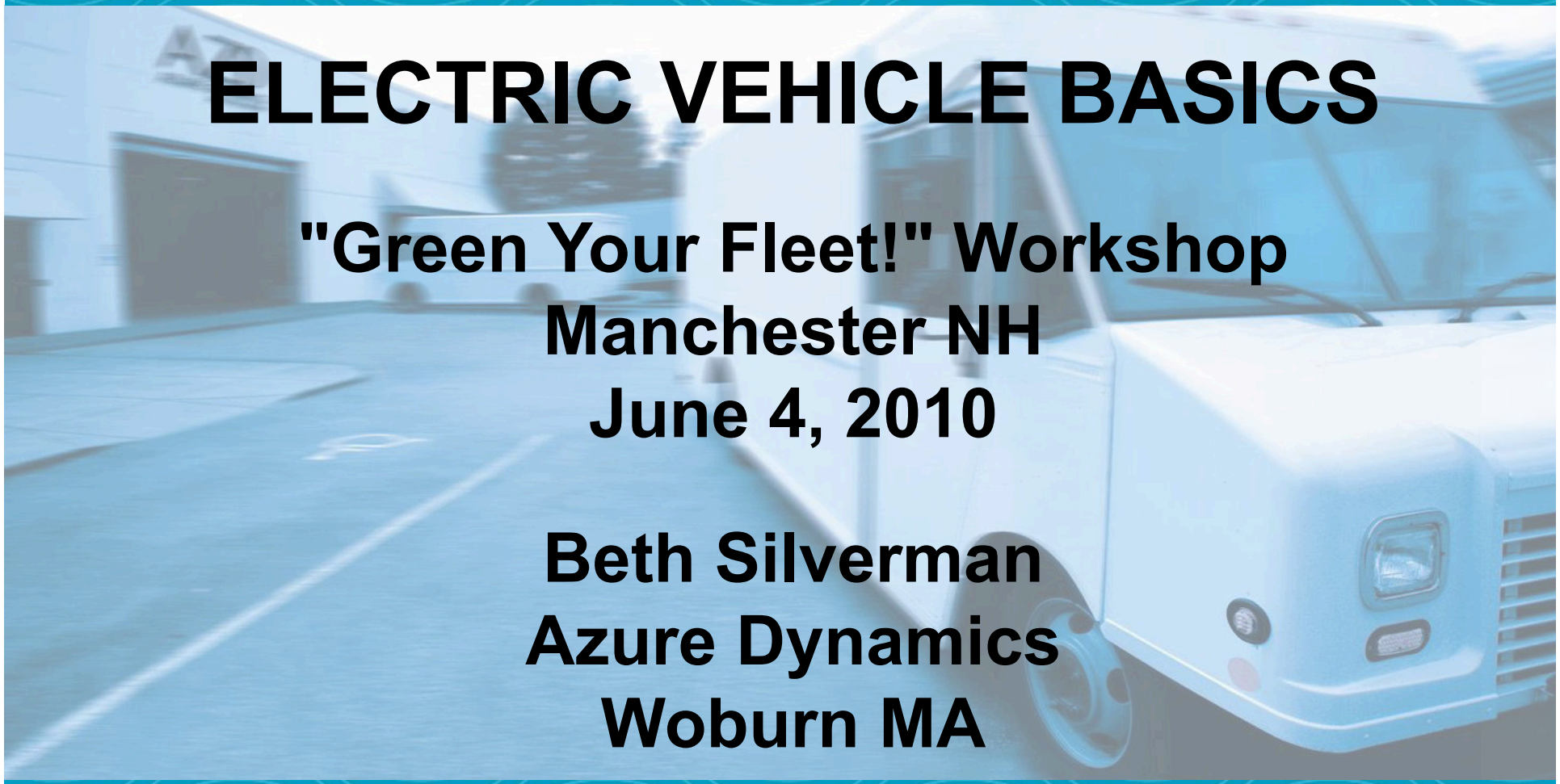
AZD
AZURE DYNAMICS
part of the solution



ELECTRIC VEHICLE BASICS

"Green Your Fleet!" Workshop
Manchester NH
June 4, 2010

Beth Silverman
Azure Dynamics
Woburn MA

Who is Azure Dynamics?

- **Formerly Solectria Corporation, since 1989**
- **Azure and Solectria merged in 2005**
- **Azure leads industry in HEV and EV powertrain solutions for vehicle classes 1 – 4**
- **Public company -- symbol AZD on TSX**



Driving a world of difference®

AZD

Azure Facilities & Employees

WOBURN MA USA: component development

- **50 employees**
- **77,000 sq ft facility**

VANCOUVER BC CANADA: controls development

- **50 employees**
- **18,000 sq ft facility**

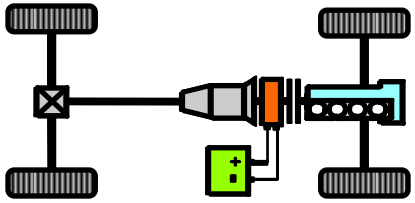
DETROIT MI USA: headquarters

- **35 employees**
- **35,000 sq ft facility**

TORONTO ON CANADA: product support

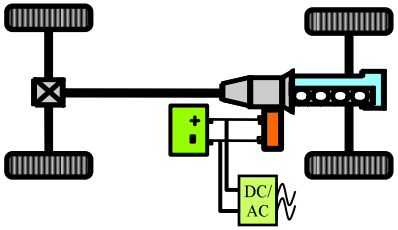
- **5 employees**

What We Build



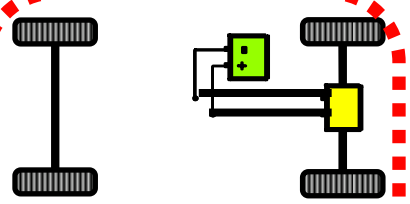
PARALLEL HYBRID

Mechanical connection between engine and electric drive motor. Motor also used as generator during braking.



LEEP

"Low Emissions Electric Power" stores energy from PTO-driven generator for engine-off hydraulics or refrigeration.



ELECTRIC

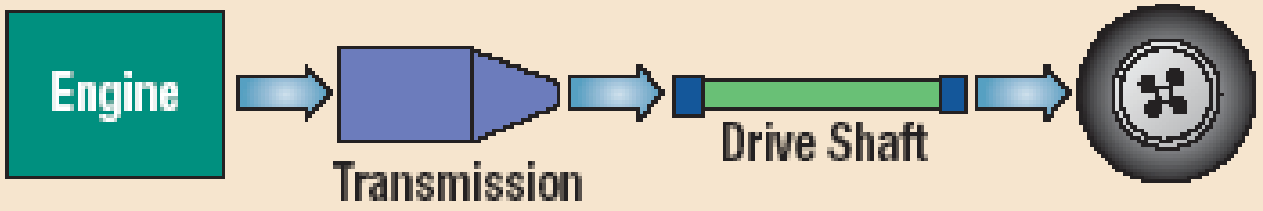
Battery stored energy drives vehicle via electric motor.

Thomas Edison Inspecting an EV - 1914

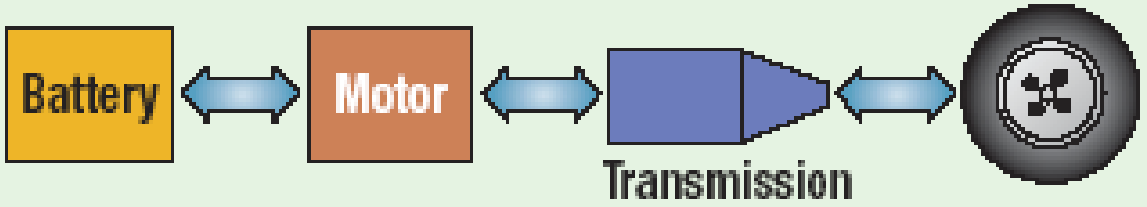
- Edison & Henry Ford planned to use Edison's nickel-iron battery to power EVs that would be charged from home wind turbines!
- 1899 was the zenith of America's EVs – the year they outsold all other types of cars.
- EVs enjoyed success into 1920s; production peaked in 1912.

Electric vs. Conventional Vehicles

Conventional Internal Combustion Engine Powerflow



Electric Vehicle Powerflow



- **Some EVs do not require a transmission.**
- **ICEs get energy from petroleum (gas, diesel, NG, ethanol, etc.)**
- **EVs get energy from batteries, usually recharged from the grid.**

EV Components/Design Considerations

- Batteries – lead-acid, NiCd, NiMH, lithium, others
- Motor – DC, AC induction, permanent magnet
- Motor controller
- Battery charger
- Heating and air conditioning
- Gauges and monitoring
- Control strategy – potentiometer or CAN "drive by wire"
- Interface with VCU for airbags, ABS, ESC, etc.

EV Design Tradeoffs

- Battery cost, size, weight, vehicle range
- Motor cost, size, weight, power
- Motor controller cost, complexity
- Air-cooled or liquid-cooled components?
- Vehicle speed, acceleration, hillclimbing
- Transmission or not?
- Battery charger cost, charging rate, on/offboard
- Auxiliary power for 12V loads
- HVAC

EV vs. Gas Cost per Mile

Fuel Cost Per US Gallon	$3.00
MPG on Gasoline	20
Cost per mile - Gasoline	$0.15
Electricty Cost - Per KWh	$0.10
Electric Usage - KWh / Mile	0.333
Cost Per Mile - Electricity	$0.03

Many advanced battery packs are now expected to last the life of the vehicle.

Pros and Cons – EVs and ICEs

ICE Vehicles

- Lower initial cost
- Fueling infrastructure exists
- "Infinite" range
- Service personnel trained
- Known residual values
- Don't have to plug in
- "The way it's always been"

Electric Vehicles

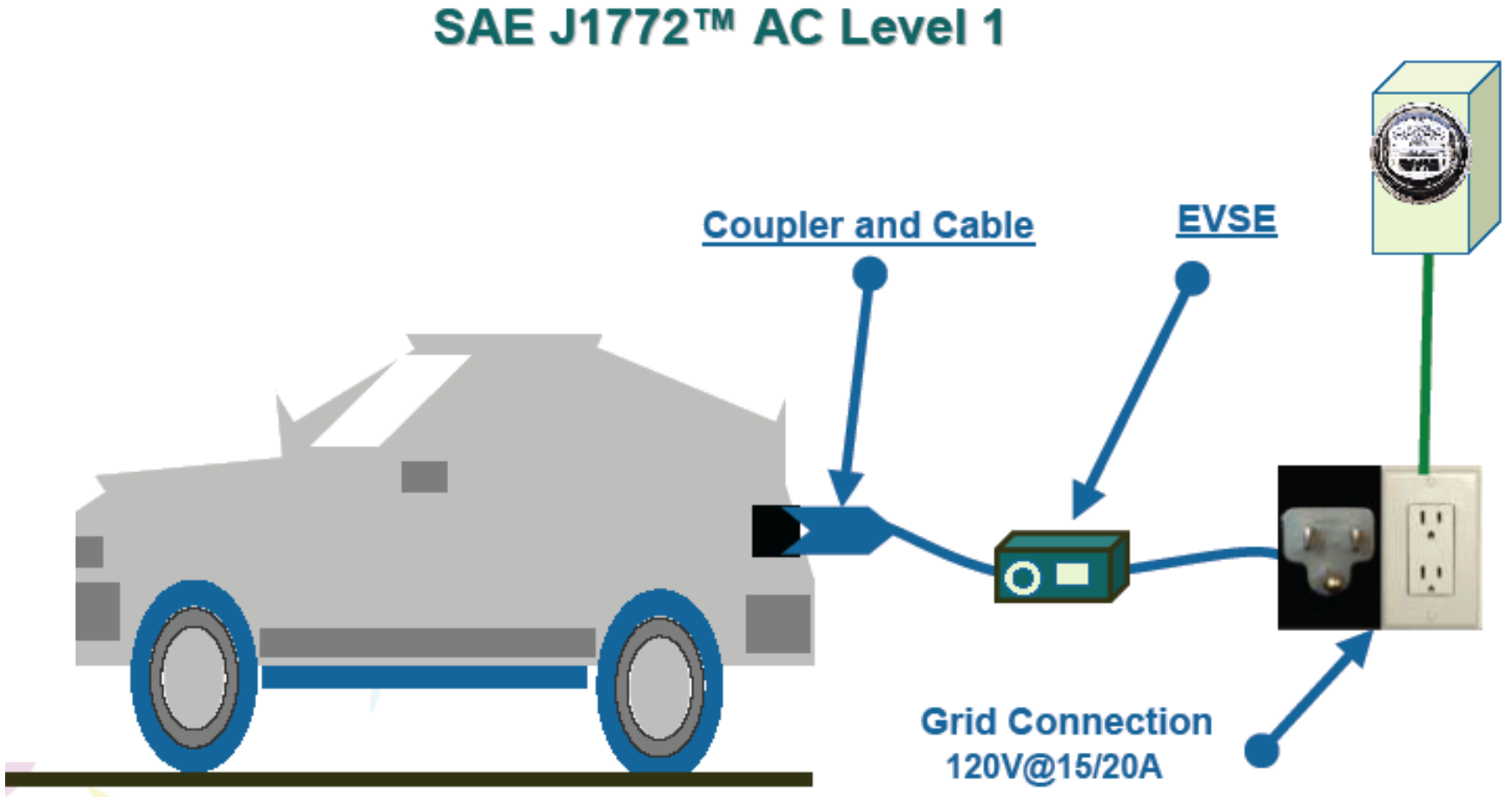
- Lower operating/maint. costs
- Zero emissions/GHG
- Reduced noise
- No refueling time
- Automatic "anti-idle"
- Green/high tech image
- Domestic energy supply
- Parking/HOV lane incentives
- Prepare now for the future

EV Charging – SAE J1772

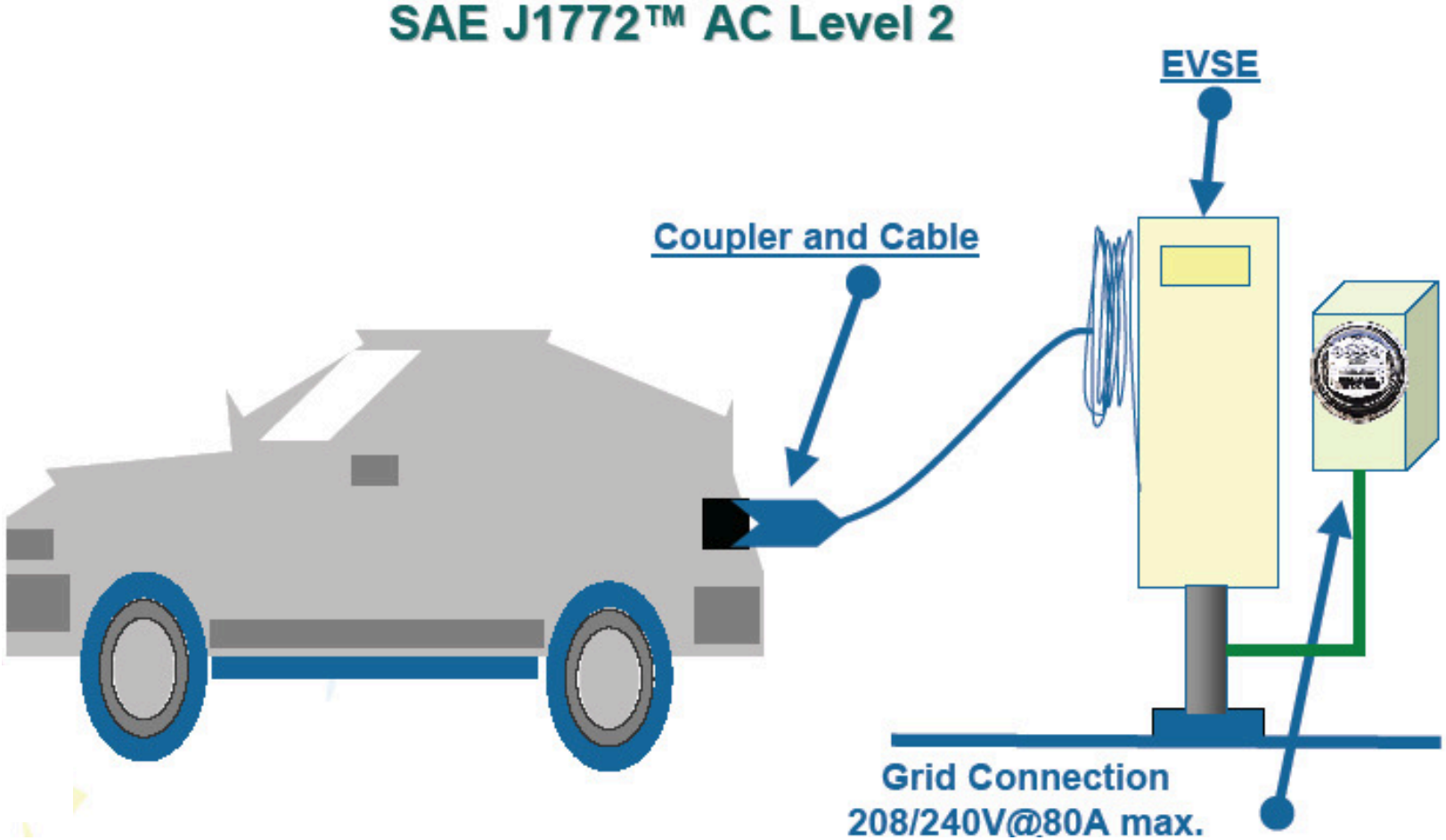
- AC Level 1 charging, on-board
  - 120VAC, single-phase 16A peak rate on 20A circuit
- AC Level 2 charging, on-board
  - 240VAC, single-phase 80A peak rate per NEC 625
- DC charging, off-board, under development
  - 300-600VDC, 3-phase, 150A - 400A rates proposed

Electric Vehicle Supply Equipment "EVSE" is not a charger, but is everything else (connectors, conductors, outlets, etc.) specifically for the purpose of safely delivering energy to EV from premises wiring.

EV Charging – SAE J1772

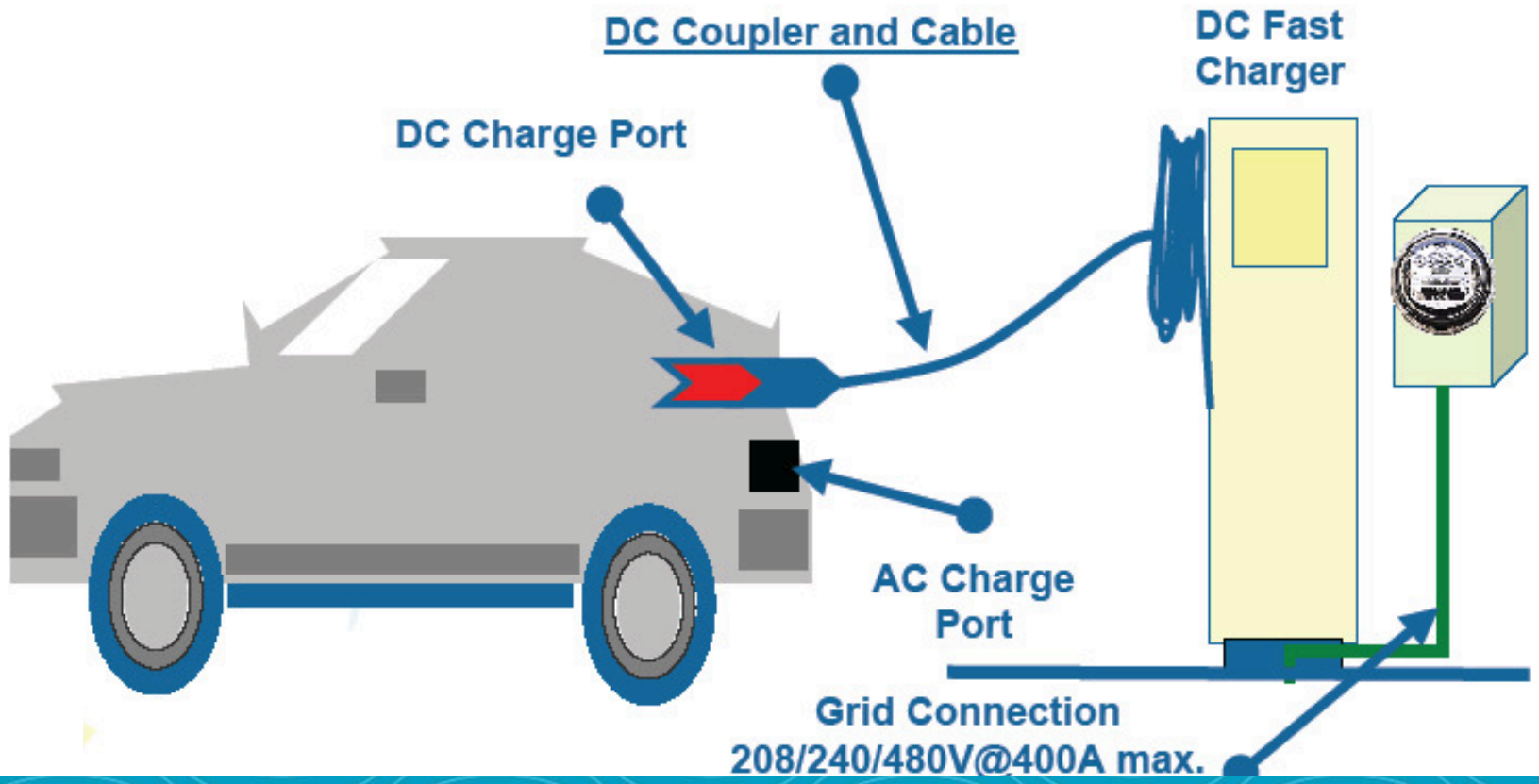


EV Charging – SAE J1772



EV Charging – SAE J1772

SAE J1772™ DC Off-Board Charging



"Smart Charging"

Spectrum of technologies involving plug-in vehicles interacting with the grid beyond simple battery charging

- **Time-of-use rates**
- **Demand response programs**
- **Critical peak pricing**
- **Charger "load" shaping**
- **Maximize capture of renewable generation**
- **Vehicle to Home (V2H) or Vehicle to Grid (V2H)**
- **Frequency modulation**

Azure Dynamics - Ford Transit Connect Electric

- Working closely with Ford
- Dedicated small commercial van proven in Europe, 700,000+ sold since 2003
- JCI-Saft Li-ion battery pack, 28 kWh
- Prototypes 4Q2010, production 1Q2011

- Expected range 70-80 miles per charge, 6-8 hr recharge @ 240V/30A
- 5005 lbs GVW, expected payload 1000 lbs
- 75 mph top speed
- 20% gradeability

Azure Dynamics - Ford Transit Connect Electric

DUAL BADGE

- Targeting utilities, governments, academia, businesses requiring small, short-range delivery vehicles
- "Lead customers" in U.S. includes AT&T; will be buying at least 10
- Announced introduction of TC EV in Europe for 2011
- France, Germany, United Kingdom to start
- Transit Connect Electric "drives like a car, works like a van and is engineered to be a tough truck."

Force Drive Electric System in Transit Connect EV

Transit Connect Electric Force Drive™ - Specifications

BATTERY ELECTRIC PROPULSION SYSTEM UPFITTED BY AZURE DYNAMICS

- 28 kWh Lithium-Ion Battery (supplied by Johnson Controls-Saft)
- Range up to 80 miles, drive cycle dependent
- Charge time 6-8 hrs with 240V/30A supply
- Max speed: 75mph
- Able to ascend up to a 20% grade
- Ambient Operating Temp -30F to 120F

  Lower temperatures require pre-conditioning.

  Some power reduction may occur above 110F.

PAYLOAD OFFERINGS

- GVW—5,005 lbs
- Maximum Payload 1000 lbs (estimated)
- Maximum Interior Cargo Volume 135 ft^3

SAFETY FEATURES

- Fully FMVSS Certified
- Collapsible Steering Column
- Tire Pressure Monitoring System
- Driver and Front Passenger Air Bags and Front Seat Side Impact Air Bags
- Available Roll Stability Control™ (RSC®)

EXTERIOR ATTRIBUTES

- 114.6 in. Wheelbase and High Roof
- XLT Trim Package
- 2nd Row Sliding Doors on Both Sides
- Exterior Rear Panel Perfect for Advertising

Specifications preliminary and subject to change at introduction.

Other Available (or soon to be) EVs

- **Low speed "NEVs" -- Miles, GEM, ZENN, Reva, ZAP, etc.**

- **Highway-capable passenger EVs -- Nissan Leaf, Tesla, Mitsubishi iMEV, Ford Focus, BYD Auto, Coda, etc.**

- **Highway-capable truck EVs -- Smith Electric Newton, Navistar eStar, ZeroTruck, etc.**

Electric Vehicles - Why Buy?

- **Commercial and fleet users often travel predictable, short-range stop-and-go routes - EVs makes sense.**
- **Energy cost ~1/5 at 10¢/kWh, $3.00/gal replacing a 20 mpg vehicle.**
- **For fleets seeking sustainable solutions, Azure's Transit Connect EV provides a zero-emissions option.**

Questions?